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Diurnal Warming in the North Sea & Baltic Sea

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†Centre for Ocean & Ice (COI), Danish Meteorological Institute (DMI).

June 24, 2010

Motivation

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5. Impact on wind energy production

Data & Methods

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- Sensitivity Analyses of the night-time reference fields
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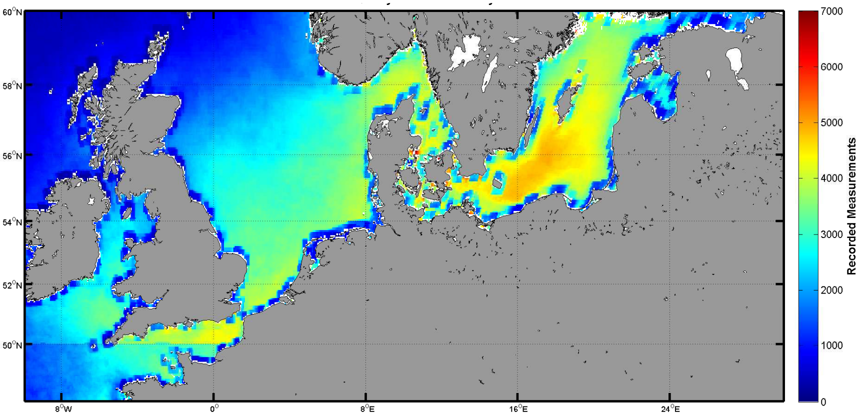
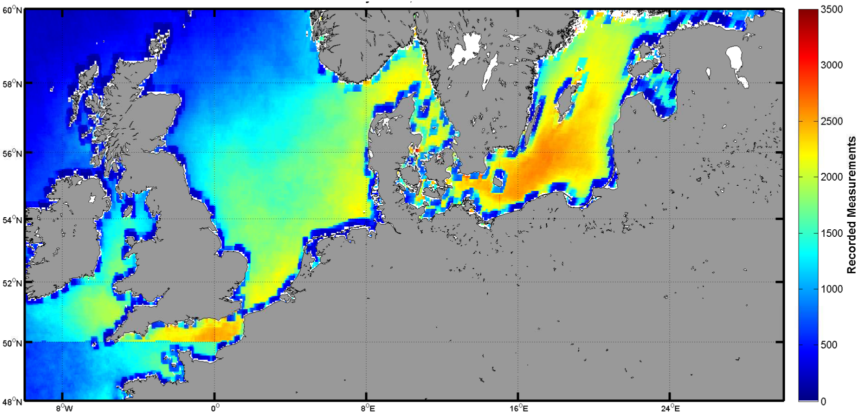
- Diurnal Warming Statistical Analyses

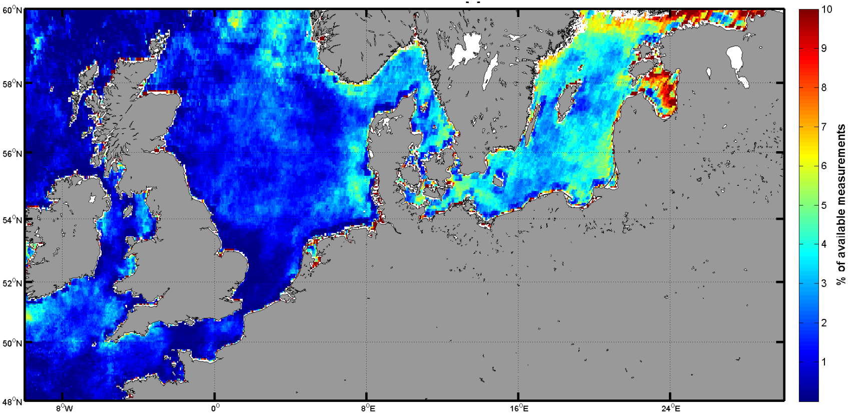
S.E.V.IR.I Quality 5 Data



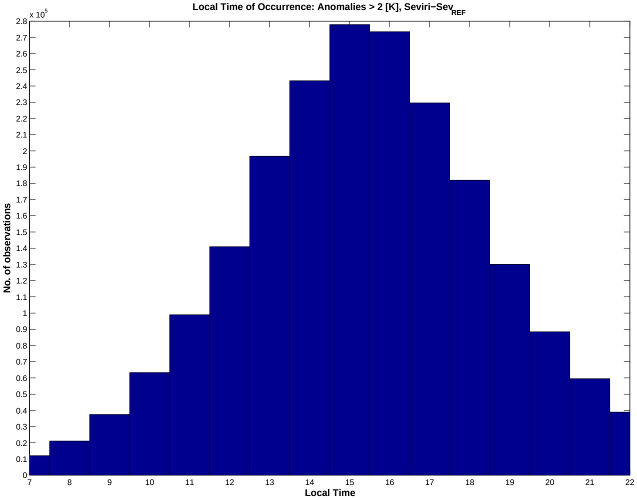
Local Time 08-20



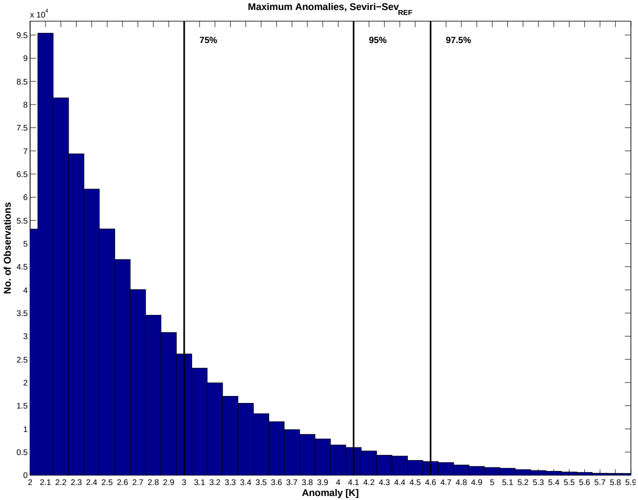
Frequency of Anomalies >2 [K]



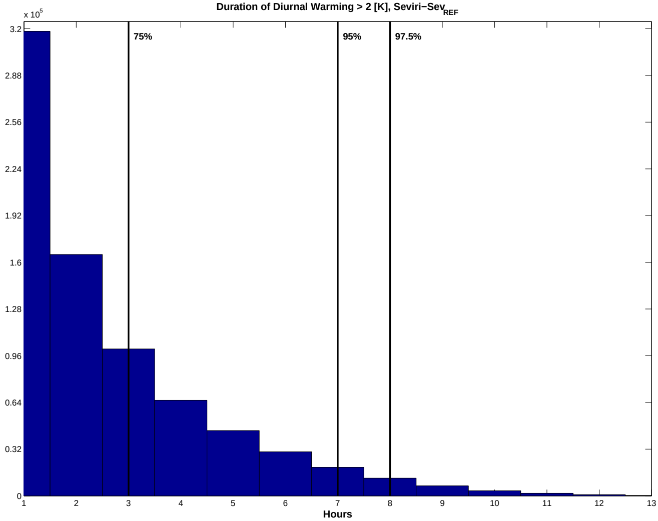
Time of Occurrence



Maximum Anomalies



Duration


Duration of Diurnal Warming > 2 [K], Seviri−Sev_REF
x 10^5
3.2
2.88
2.56
2.24
1.92
1.6
1.28
0.96
0.64
0.32
0
75%
95%
97.5%
1 2 3 4 5 6 7 8 9 10 11 12 13
Hours

Size

1. Minimum size: 5 grid cells (17.7 km^2)

Size

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2. Magnitude of warming: anomalies >2

Size

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3. Neighboring conditions

Size

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   * For every pixel with anomaly>2, "search" 8 neighboring pixels

Size

1. Minimum size: 5 grid cells (17.7 km^2)
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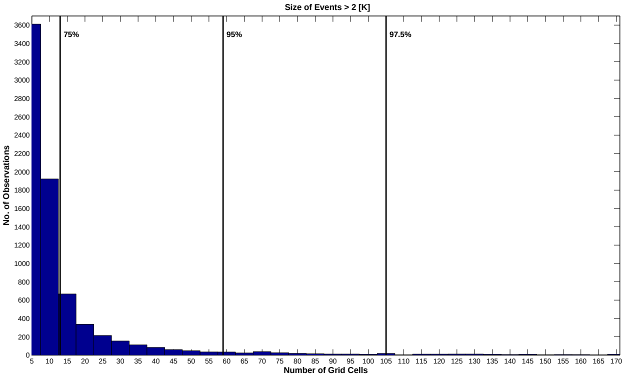
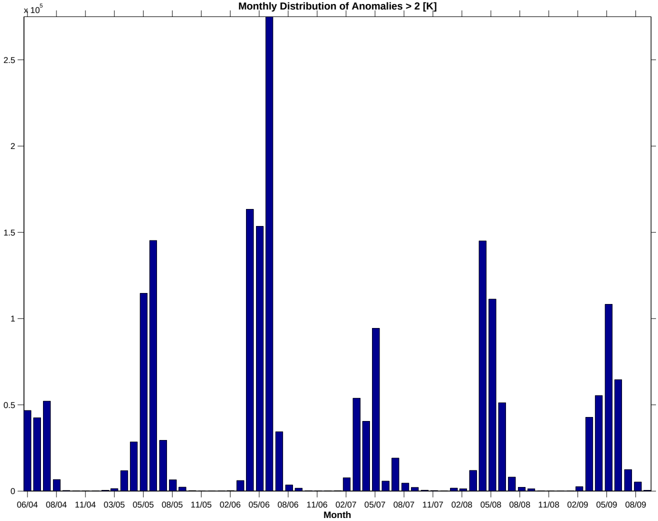
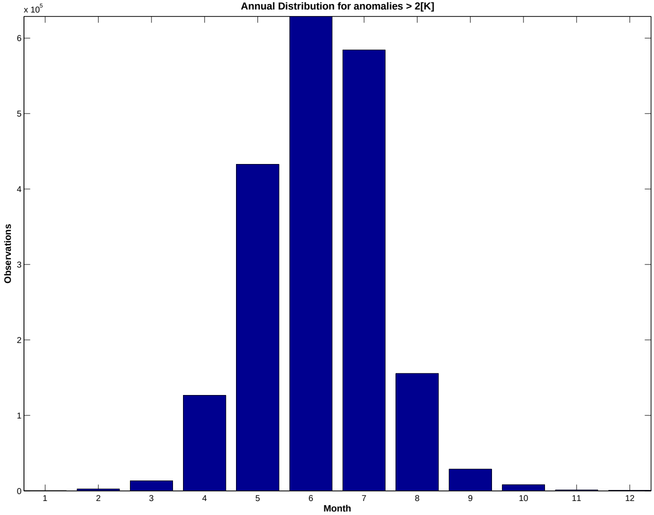


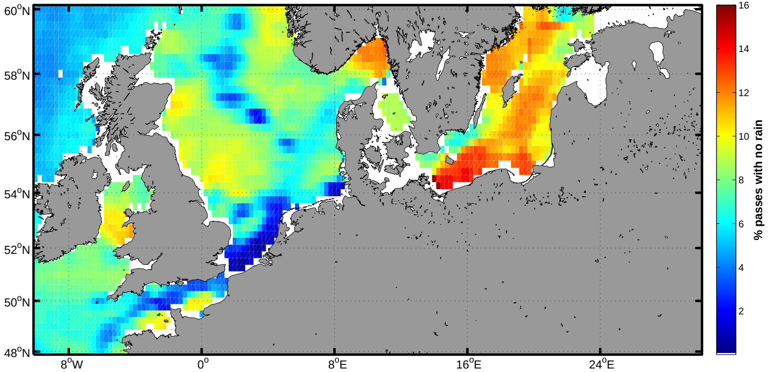
Monthly Distribution: Anomalies > 2 [K]



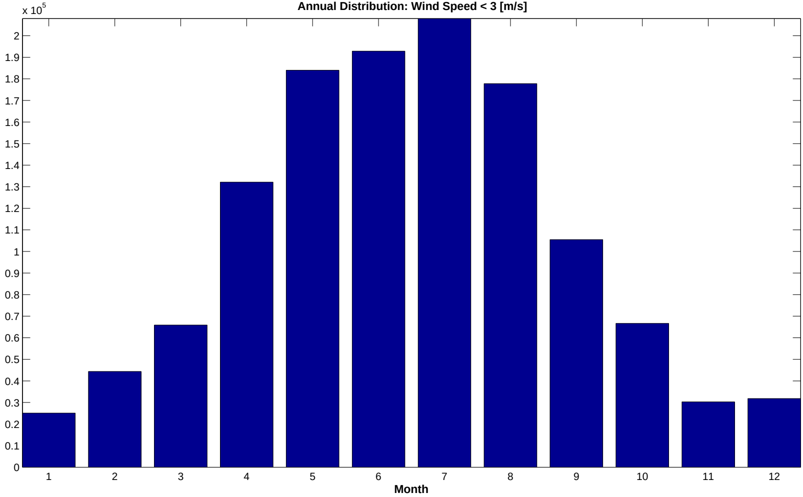
Annual Distribution



QuikSCAT Winds



Annual Distribution



Time Series

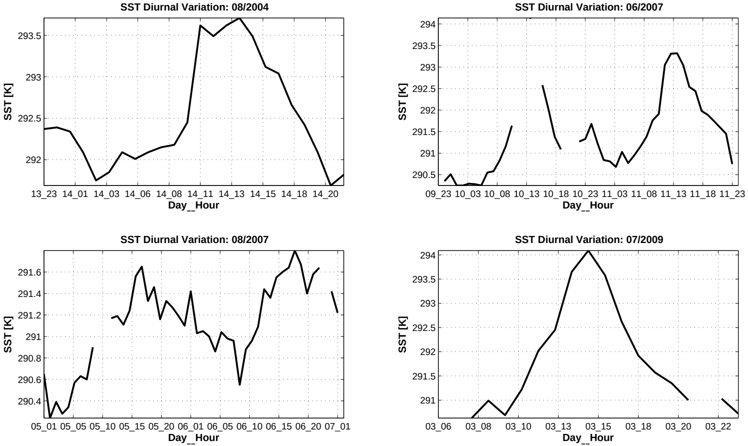
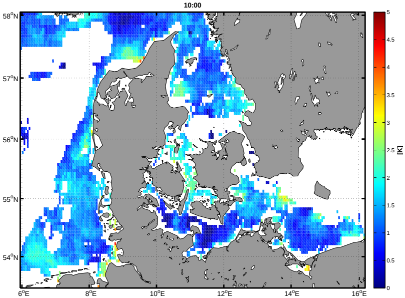
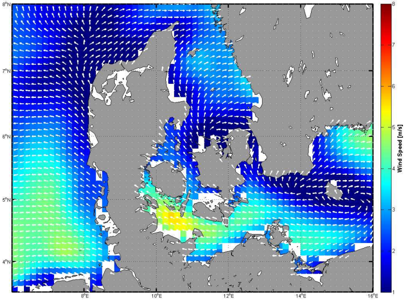
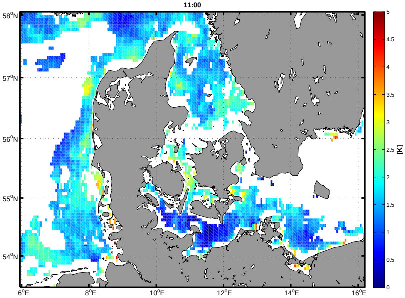


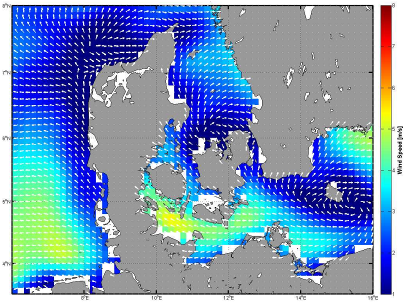
Figure: Time series of sea surface temperature, for Horns Rev (lat:53.7 N, lon:7.78 E)

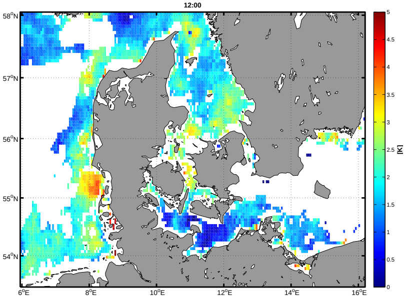
Diurnal Warming Event: 03/07/2009

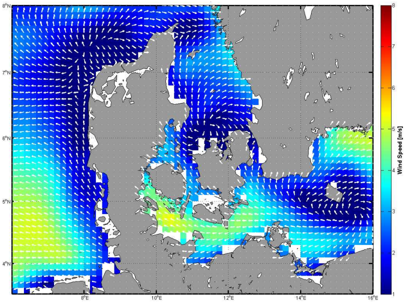


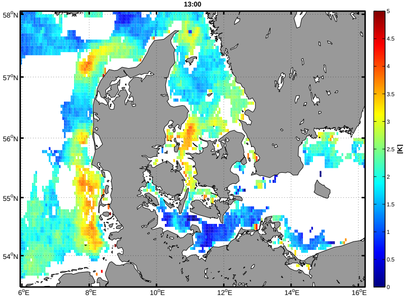


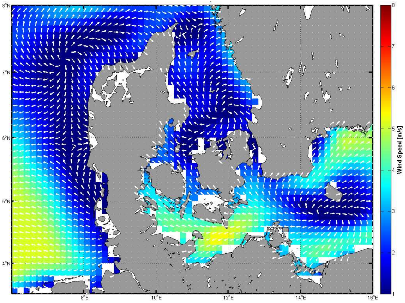

11:00
58°N
57°N
56°N
55°N
54°N
6°E
8°E
10°E
12°E
14°E
16°E
[K]
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

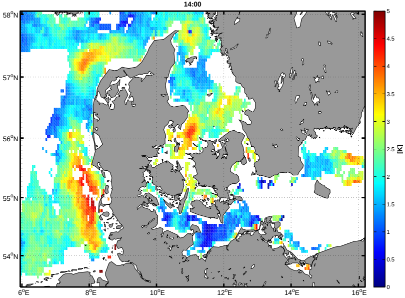

8°E
10°E
12°E
14°E
16°E
Wind Speed [m/s]
1
2
3
4
5
6
7
8

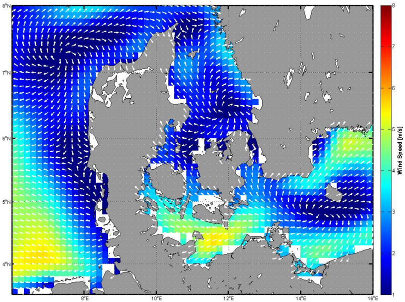

12:00
58°N
57°N
56°N
55°N
54°N
6°E
8°E
10°E
12°E
14°E
16°E
[K]

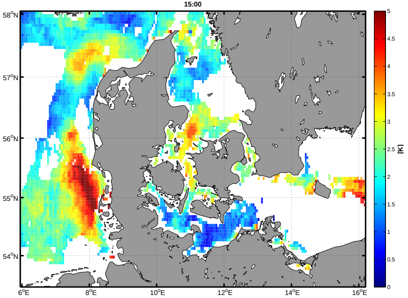

Wind Speed [m/s]
8°E
10°E
12°E
14°E
16°E

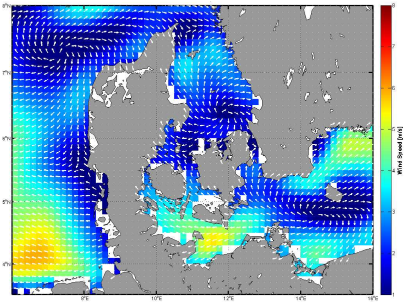

13:00
58°N
57°N
56°N
55°N
54°N
6°E
8°E
10°E
12°E
14°E
16°E
[K]
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0

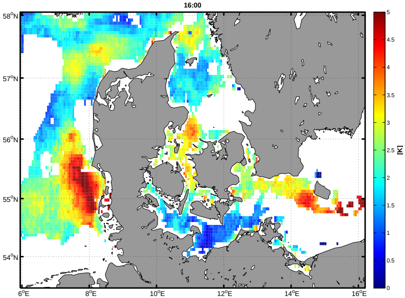

8°E
10°E
12°E
14°E
16°E
Wind Speed [m/s]
8
7
6
5
4
3
2
1

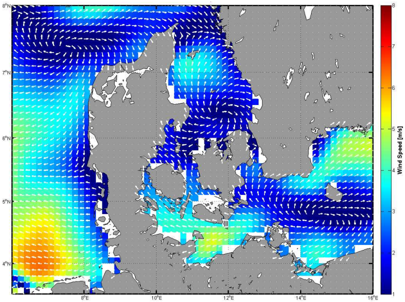

14:00
58°N
57°N
56°N
55°N
54°N
6°E
8°E
10°E
12°E
14°E
16°E
[K]
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

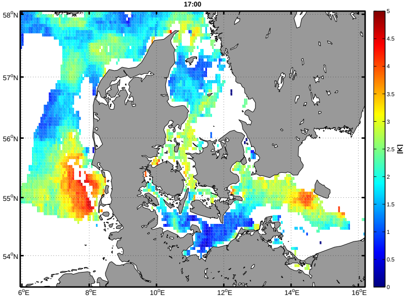

8°E
10°E
12°E
14°E
16°E
Wind Speed [m/s]
1
2
3
4
5
6
7
8

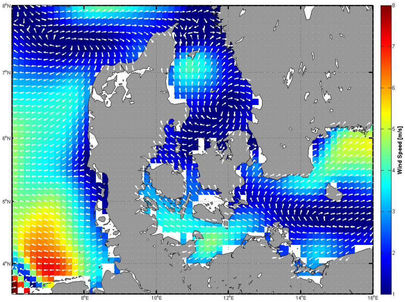

15:00
58°N
57°N
56°N
55°N
54°N
6°E
8°E
10°E
12°E
14°E
16°E
[K]
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0

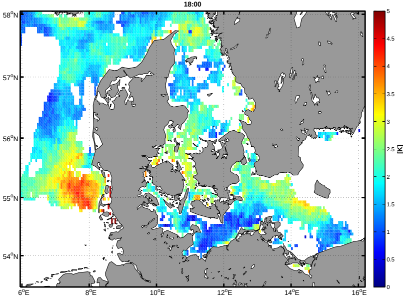

Wind Speed [m/s]
8°E
10°E
12°E
14°E
16°E
8
7
6
5
4
3
2
1

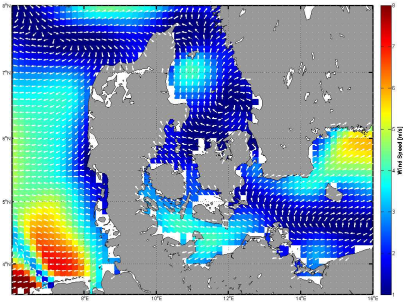

16:00
58°N
57°N
56°N
55°N
54°N
6°E
8°E
10°E
12°E
14°E
16°E
[K]
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0

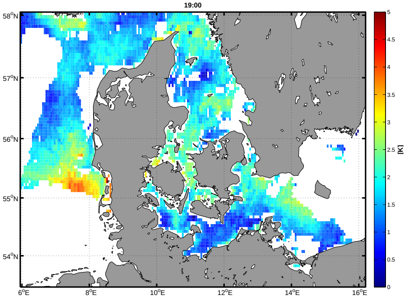

8°N
7°N
6°N
5°N
4°N
8°E
10°E
12°E
14°E
16°E
Wind Speed [m/s]
8
7
6
5
4
3
2
1

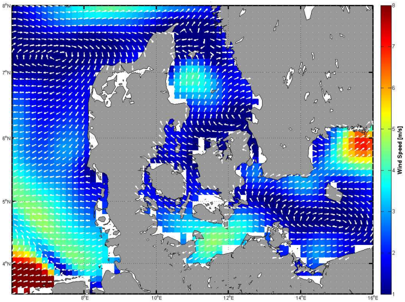

17:00
58°N
57°N
56°N
55°N
54°N
6°E
8°E
10°E
12°E
14°E
16°E
[K]
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

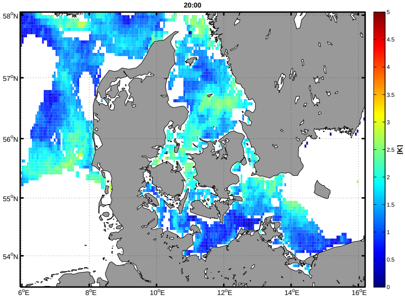

Wind Speed [m/s]
1
2
3
4
5
6
7
8
8°E
10°E
12°E
14°E
16°E

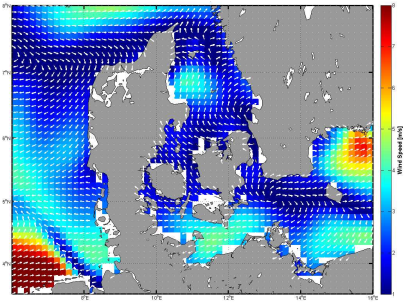

18:00
58°N
57°N
56°N
55°N
54°N
6°E
8°E
10°E
12°E
14°E
16°E
[K]
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5


8°N
7°N
6°N
5°N
4°N
8°E
10°E
12°E
14°E
16°E
Wind Speed [m/s]
1
2
3
4
5
6
7
8

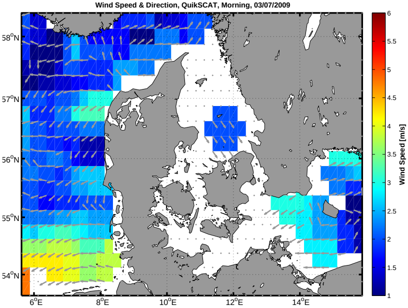

19:00
58°N
57°N
56°N
55°N
54°N
6°E
8°E
10°E
12°E
14°E
16°E
[K]
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

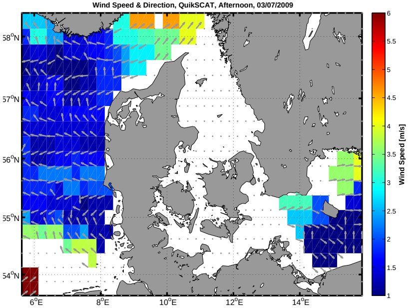

Wind Speed [m/s]
1
2
3
4
5
6
7
8
8°E
10°E
12°E
14°E
16°E


20:00
58°N
57°N
56°N
55°N
54°N
6°E
8°E
10°E
12°E
14°E
16°E
[K]
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0

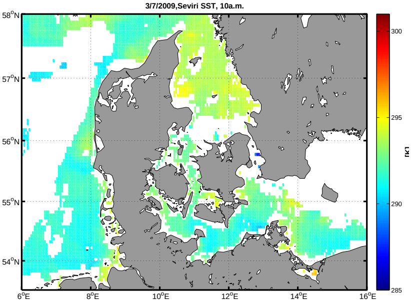

Wind Speed [m/s]
8
7
6
5
4
3
2
1

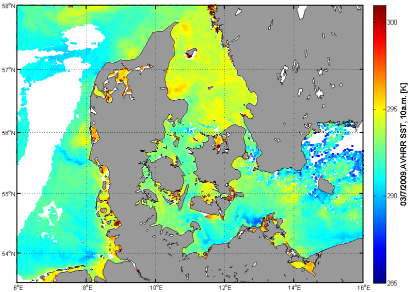
QuikSCAT


Wind Speed & Direction, QuikSCAT, Morning, 03/07/2009
58°N
57°N
56°N
55°N
54°N
6°E
8°E
10°E
12°E
14°E
Wind Speed [m/s]
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1


Wind Speed & Direction, QuikSCAT, Afternoon, 03/07/2009
58°N
57°N
56°N
55°N
54°N
6°E
8°E
10°E
12°E
14°E
Wind Speed [m/s]
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1

S.E.V.IR.I vs. AVHRR





S.E.V.IR.I Fluxes

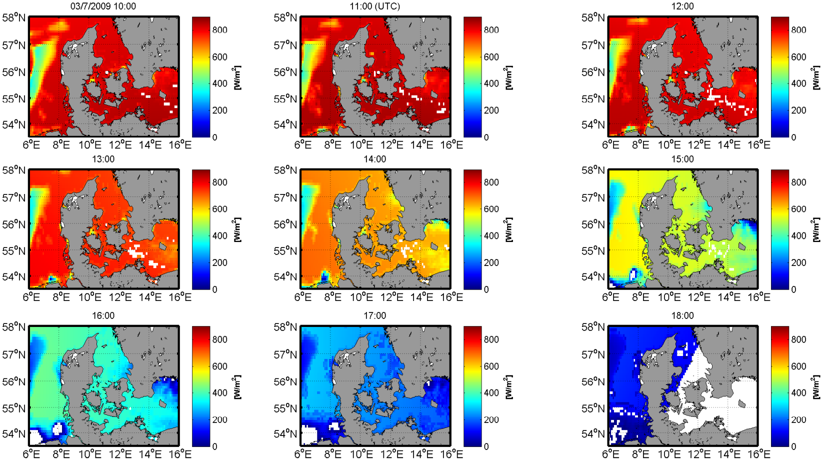


Figure: Surface Solar Irradiance S.E.V.IR.I 03/07/2009

Secchi Disk

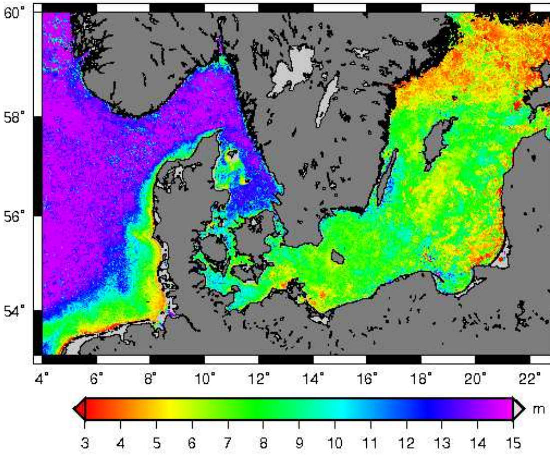


Figure: Mean monthly Secchi Disk depth for 07/2009, from *marcoast.dmi.dk*

Conclusions

1. Diurnal Warming does occur in latitudes $> 50^o$ North

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Conclusions

1. Diurnal Warming does occur in latitudes $> 50^o$ North
2. The Baltic is more susceptible to diurnal warming than the North Sea
3. Areas with high percentage of DW events match those with high percentage of low winds
4. Most cases do not exceed 3 [K]

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